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AN INSTITUTIONAL OUTBREAK OF CEREBROSPINAL MENINGITIS RESTRICTED BY THE ELIMINATION OF CARRIERS.*†

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The asylum, a semi-private eleemosynary institution, is owned and conducted by the Sisters of Charity and is supported by state and private contributions. The object of the charity is the care of forsaken infants and orphan children up to the age of six years. There are accommodations for 250 children, 60 of whom are cared for at the country home.

The children are divided into three groups, the largest of which comprises those above four years of age. These are about 165 in number, but 60 of them are kept at the country home. It was among these kindergarten children at the city house that the outbreak of meningitis occurred.

This asylum has been singularly free from epidemics of all kinds and in the last eight years there had been but two cases of cerebrospinal fever, one in 1904, the other in the spring of 1905. From November, 1909, to April 28, 1910, however, four cases occurred, an interval of two months elapsing between the first and second, and of three months between the second and third. The fourth, however, occurred six days later and it was then, fearing the outbreak might assume epidemic proportions, that the Health Department was requested to make an investigation. This consisted, in part, of a careful bacteriological study of the nose and throat of each child in this group, and of every person who had been in contact with these children. All carrier cases were isolated until the treatment with antimeningitis serum cleared up the condition, quarantine being raised only after two consecutive negative cultures from both the nose and throat. There have been no more cases of menin-

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gococcic meningitis and we believe that, by this precaution, an epidemic was prevented.

The nature of the outbreak suggested that the source of infection was the presence of carriers in the asylum and careful consideration convinced us that such was the case. The long intervals between all the cases except the last two would preclude all other explanations save the one mentioned and the possibility of the disease being introduced from without. The latter assumption seemed highly improbable in view of the fact that meningitis was not prevalent in Baltimore at the time. It was, therefore, determined to make a painstaking search for carriers in the infected portion of the home. This necessitated the making of cultures from the nasal and naso-pharyngeal secretions of 94 orphans and of three other inmates who had been in contact with these children.

Although, at the time, we were cognizant of the fact that the meningococcus had been found in the nose and throat of healthy contacts, we were not aware that any similar effort had been made to control an institutional epidemic. In a review of the literature we found that up to and including 1903 the meningococcus had been isolated from the nose and naso-pharnyx of contacts only three times: once each by Kiefer, Albrecht and Ghon, and Lord. Kiefer developed a purulent rhinitis while engaged in a study of the meningococcus and was able to isolate this micro-organism from his nasal discharge. Albrecht and Ghon obtained it from the naso-pharyngeal secretion of a contact. Lord demonstrated it in the nasal secretion of a physician who had been daily in the Throat Room of the Massachusetts General Hospital, and who at the time had a severe rhinitis.

In the interim between 1903 and the present time there have been numerous cases reported, a partial review of the literature showing several hundred. Thus, Weichselbaum and Ghon isolated this organism from the nasal secretion of three persons exposed to meningitis, identifying them culturally. Goodwin and von Sholly studied the nasal mucus of 45 healthy contacts, and in 5 meningococci were found. From the nasal secretion of 2 out of 55 medical students they isolated an organism which culturally, morphologically, and tinctorially resembled the meningococcus. These strains, however, by absorption tests, were proved not to have the specific agglutinins of the meningococcus.

Von Lingelsheim obtained the meningococcus in 26 out of 289 healthy persons examined, these embracing 213 near relations, 40 close acquaintances, 30 nurses, and

6 physicians. Of the 26 carriers, 23 belonged to the first class and 3 to the second. He also found that 4 of 56 school children were carriers. In 1906 he reported upon 514 examinations of the nasal and naso-pharyngeal secretions of 471 individuals not suffering from meningitis. Three hundred and eighty-seven of the cultures were from 346 persons in more or less intimate contact with cases of epidemic cerebro-spinal meningitis. Two hundred and seventy-four were from 234 near relations, 87 from friends in infected houses, 3 from physicians, and 33 from 22 nurses. Twenty-eight of the 387 cultures contained meningococci. Ninteen relations, 4 friends, and 1 nurse proved to be infected contacts. The 87 friends included the 56 school children previously mentioned. The remaining 127 cultures were from 125 persons suffering from some disease other than meningitis, and none of these proved positive. In none of these cases was there a history of contact with meningitis.

Kolle and Wassermann examined the nasal secretion of 114 persons and isolated the meningococcus in 2 instances. One case was a girl who had had symptoms suspicious of meningitis; the other was a man whose child had probably suffered from the disease. In none of these cases did the microscopic examination of smears show intracellular diplococci which resembled the meningococcus. Ostermann isolated the meningococcus from the naso-pharyngeal mucus of 17 out of 24 members of 6 families. Kutscher in his studies found 6 carriers, one being the father of a child who had died of cerebrospinal fever. Four others were soldiers who were being treated in a garrison hospital for various catarrhal affections of the upper air passages, rheumatism, scarlet fever, and typhoid fever. In all, 56 soldiers were examined.

During the epidemic of 1905, Dieudonné examined the noses of 29 soldiers in a garrison hospital for the presence of the meningococcus, and found 4 of these were carriers. He also examined the nasal and pharyngeal secretions of 39 soldiers in a room in which several cases of epidemic cerebrospinal meningitis had occurred. From 5 of these he isolated the meningococcus. These contacts had been very closely associated with two of the cases of meningitis. Hasslauer also reports this same investigation. Bochalli found that 10 of 16, or 62 per cent of the people occupying rooms of patients were meningococcus carriers. Trautmann in his studies discovered that 100 per cent of one family were infected contacts, while 75, 50, 30, 25, and 20 per cent of other families were carriers; the average for all was 70 per cent.

Friese and Müller made 114 examinations of the naso-pharyngeal secretions of 36 sick soldiers, not, however, suffering from meningitis. Of these 79 proved positive, this representing 28 different men. In 3 cases the meningococcus was still present at end of three months. Of 60 healthy soldiers, 28 gave positive and 32, negative results. They also found 12 carriers among civilians.

Of 26 persons who had been associated with 2 cases of meningitis, Selter found 8 were carriers; while of 25 persons who had been in contact at the factory with either the father or sister of one of these cases, 7 were carriers. In another infected family he isolated the meningococcus from 6 healthy persons. He also obtained this organism from 2 out of 18 persons associated at the work shop with the father of this family, and from one other person working in a room on the opposite side of the shop. Four members of a third infected family also showed the presence of the meningococcus in the naso-pharyngeal secretion. Selter discovered that 3 of 35 patients at a nose and ear polyclinic were carriers. None of these had been in contact with meningitis.

Bethge described an epidemic in an orphan asylum in which 9 out of 187 inmates developed cerebrospinal meningitis. In April, 1909, he began a study of this outbreak and isolated the meningococcus from 60 healthy contacts. Of these 57 were isolated and all received local treatment. Following this the outbreak ceased.

Mayer made bacteriologic examinations of the troops in Munich where there had been an epidemic the year before: Two per cent of 9,111 healthy soldiers were found to be carriers. A second examination was made of 1,911 of these men, and he obtained the meningococcus from 2.46 per cent. He believes that the organism is widely distributed both during and after an epidemic.

A few of the cases reported were persons who had not, so far as could be determined, been in contact with meningitis. Thus, as already mentioned, Selter was able to isolate the meningococcus from 3 of 35 patients at a nose and ear polyclinic, not one of whom had been associated with a case of meningitis. However, it has been the experience of most observers that the meningococcus is only isolated from the nose and throat of such healthy persons as have been in contact with cerebrospinal fever. Thus, Hasslauer made cultures from the throats of 192 persons giving no history of contact with meningitis; in none of these did he find the meningococcus. Again, Davis made 200 examinations of sputum and cultured 150 throats and failed to find this organism.

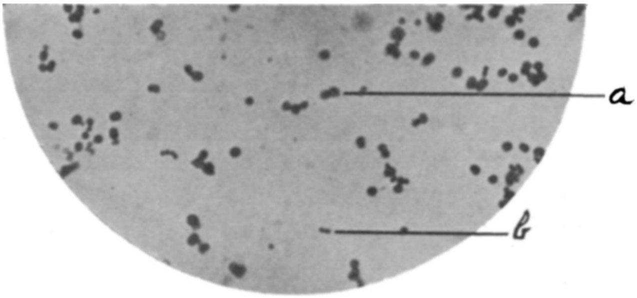
We have constructed the following table which shows the percentage of contacts from whom typical meningococci were isolated:

Observer	Total Examinations	Positive	Percentage
Goodwin and von Sholly	45	5	11.1
Von Lingelsheim	346	24	6.9
Ostermann	24	17	70.0
Friese and Müller	60	28	46.6
Selter	51	15	29.0.
Bethge	187	60	32.0
Hachtel and Hayward	97	15	15.4
Total	810	164	20.2

ORIGINAL INVESTIGATION.

Swabs from the nose and nasal pharynx were rubbed over Loeffler's blood serum and incubated 18 hours at 37° C. Slides from these were stained according to Gram's method and counterstained with Bismarck brown. All cultures showing Gram-negative organisms morphologically like the meningococcus were selected for further study. A loop from each of these was carried through several water blanks and rubbed over four slants of Loeffler's blood serum and these cultures incubated. Typical discreet colonies were then picked and stained as above. If suspicious, the organisms were then subjected to careful cultural study, and their pathogenicity for white mice was determined. In this way we studied 194 cultures from 97 different people, and were able to demonstrate the meningococcus 18 times, this representing 15 carriers. It will thus be seen that from three of the children we isolated it from both the nose and throat; from the other 12 it was only found in the naso-pharyngeal secretion. The percentage of carriers in this instance was, therefore, 15.4, which is between the percentage of Goodwin (11.1 per cent) and that of Bethge (32 per cent). Besides the meningococcus, we also isolated the micrococcus catarrhalis in 24 instances, and the various strains of this organism were also subjected to careful cultural study, animal inoculations, and opsonic experiments.

Morphology and staining characteristics.—In all cases the meningococcus-like organisms corresponded to the usual description, being Gram-negative, bean-shaped cocci, as a rule arranged in pairs with the flat surfaces apposed. There was considerable variation in the size and in the staining qualities of the individual organisms, and the older cultures showed marked degenerative changes.



a. Micrococcus catarrhalis.
b. Meningococcus.

FIG. 1.—Showing the difference in size between the meningococcus and the micrococcus catarrhalis.

The micrococcus catarrhalis differed from the typical meningococcus only in being slightly, but appreciably, larger, and in being more nearly uniform in size. The difference in size is clearly shown in the accompanying photomicrograph of an artificial mixture of pure cultures of the two organisms. This was sufficient to enable us, after having examined cultures from 25 children, to separate the original cultures into two groups; the one including organisms which we considered meningococci, the other those we believed to be the micrococcus catarrhalis. In this manner we placed 12 cultures in the first group and 22 cultures in the second, all of which were shown by cultural and opsonic tests to be the meningococcus and the micrococcus catarrhalis respectively. In only two instances out of the last 144 cultures studied did we find diplococci which we could not thus classify, these later proving to be the micrococcus catarrhalis.

Cultural properties.—All the cultures of the meningococcus were in every respect typical. Thus, on Loeffler's blood-serum, the colonies were white, viscid, and moist, having sharply defined margins, and in some cases becoming confluent. None of them liquefied this medium.

The growth was less profuse on glycerin agar than on the blood serum, and the colonies were white, translucent, and viscid, and the borders sharply defined.

Litmus milk remained unchanged in reaction, while the growth in gelatin was not profuse nor was there liquefaction in any instance. The growth in broth was scant.

We also inoculated our cultures into sheep-serum dextrose-litmus broth, and in every case there was fermentation with the formation of acid, but never of gas; never was there sufficient acid produced to cause coagulation of the sheep-serum.

Micrococcus catarrhalis.—The colonies of this organism on Loeffler's blood serum and upon glycerin agar were somewhat larger than those of the meningococcus, and after 48 hours the outlines of the colonies showed considerable irregularity. The blood serum was not liquefied. Litmus milk remained unchanged, while the growth in gelatin was not profuse and there was no liquefaction of this medium. The action of various strains of this organism on the sheep-serum dextrose-litmus broth medium was also studied, and none of them produced the slightest acidity even after standing seven days.

It would seem, therefore, that media containing dextrose should be of inestimable value in the differentiation of the meningococcus from the micrococcus catarrhalis. Thus, Arkwright, working with 36 cultures of the meningococcus isolated from cases of cerebrospinal fever, found that 33, or 91.6 per cent, caused acid fermentation of dextrose.

Symmers and Wilson studied the action on dextrose of 60 organisms isolated from cases of epidemic cerebrospinal meningitis. In nearly all instances the medium which contained litmus became red, in a few cases bleaching preceding the reddening. Of 10 strains of meningococci from sporadic cases, 80 per cent produced acid in this dextrose medium.

Pathogenicity.—Eight strains each of the meningococcus and the micrococcus catarrhalis were inoculated intraperitoneally into white mice. In all instances the mice inoculated with the meningococcus died within 18 to 48 hours of purulent peritonitis, showing many intracellular organisms, while none of the other organisms proved pathogenic. However, different strains of the meningococcus vary so greatly in their pathogenicity that animal inoculations cannot be depended upon for the differentiation of this micro-organism from the micrococcus catarrhalis.

Agglutination.—We were unable to perform any agglutination experiments with our organisms since they died out so rapidly. However, in reviewing the literature we find such great variability in the agglutination of different cultures of the meningococcus, that we do not believe that much stress should be laid upon such experiments in the separation of the micrococcus catarrhalis from the meningococcus. Both Ghon and Selter have come to the same conclusion, the latter having found that meningococci isolated from different members of the same family vary greatly in their agglutinative reaction.

Opsonic experiments.—Houston and Rankin have found that while normal serum is opsonic for the meningococcus it is much less so for this organism than for the staphylococcus. They also found the blood of cerebrospinal fever patients highly opsonic for the meningococcus, and from comparative experiments have come to the conclusion that opsonic tests are more to be depended upon than the agglutinative reaction. Davis was originally of the opinion that there was no appreciable difference between the opsonic action of normal serum and the serum of cases of meningitis. Later he made more extended studies, and from these concluded that the serum of meningitis patients is more strongly opsonic.

Since in some former work with the meningococcus we also had found that undiluted normal serum was opsonic for this organism, but that it lost this property when used in a dilution of 1–5, we decided to employ Neufeld's method of dilution rather than Wright's technic. We employed antimeningitis serum (Flexner's) in dilutions of from 1–5 up to 1–200, using in all 15 different strengths. Equal quantities of a suspension of a 24-hour culture of the meningococcus, of washed leukocytes, and of a dilution of serum were mixed in capillary pipettes, and each of these was sealed and incubated 20 minutes. They were then opened and the contents of each spread on a slide, stained by Jenner's stain, and examined for phagocytosis. We found that what has been termed the dilution of opsonic extinction varied from 1–100 to 1–200 for our different strains.

Similar experiments were performed with our cultures of the micrococcus catarrhalis, but this serum, even at a dilution of 1–2, did not cause the leukocytes to ingest this organism. Nor was normal serum opsonic for it at a 1–2 dilution. These experiments were performed with nine strains of the meningococcus and eight of the micrococcus catarrhalis. We feel, therefore, that opsonic experiments should be of great value in the differentiation of these two organisms.

PRACTICAL METHOD FOR DETECTING CARRIERS.

In our search for the cause of this outbreak we studied most carefully the morphological, tinctorial, and biological characteristics of all the original cultures, and also of the second cultures from several of the contacts. In a purely scientific research such a procedure is necessary for the positive identification of the meningococcus. Our experience in this investigation, however, impressed us with the fact that such a method would be impracticable in practical sanitary work. We, therefore, decided to determine whether the meningococcus could be microscopically distinguished from the micrococcus catarrhalis. As previously stated we found the latter organism to be slightly larger and of more nearly uniform size than the meningococcus.

Believing that carriers are the principal source of infection in cerebro-spinal meningitis, we think that in all outbreaks such as the one here described an attempt should be made to control the healthy contacts. As it is utterly impossible in the usually overworked municipal or state laboratory to make a complete study of the organisms in each instance, we consider, in view of our personal experience, that, for the detection of meningococcus carriers, the sanitarian is justified in depending upon the microscopic examination of the mixed cultures from the nose and naso-pharynx. Certainly this is as dependable as the microscopical method of distinguishing the diphtheria bacillus from *B. xerosis* and *B. Hoffmanni.*

Therefore, whenever a local outbreak of epidemic cerebrospinal meningitis occurs, or when carrier cases are suspected, a specimen from the nose and one from the throat should be obtained on a sterile cotton swab such as is used in the ordinary diphtheria outfit. This should be rubbed over Loeffler's blood serum and after incubating from 12 to 24 hours at 37° C. the growth should be mounted on a slide and stained by Gram's method and counterstained by Bismarck brown.

The pyogenic organisms, such as the streptococcus, staphylococci, and the pneumococcus, are eliminated by this method since they stain by Gram's method. This leaves for practical consideration only the large micrococcus catarrhalis and the somewhat smaller meningococcus. These are both negative to Gram's method and stain brown with Bismarck brown. The micrococcus catarrhalis can be distinguished from the meningococcus by being slightly larger and by its more nearly uniform size. We, therefore, propose this as a routine method for searching for carrier cases and for the determination of freedom from the meningococci for the relief of quarantine or isolation.

TREATMENT.

In reviewing the literature we find very little upon the subject of the treatment of meningococcus carriers. Ostermann used boric acid followed by the use of a one per cent solution of hydrogen peroxide for 20 minutes three times a day, but this did not prove very efficacious. Dieudonné treated his cases by having them snuff sozoiodolat; this, however, proved valueless. Selter believes that little is to be accomplished by any line of treatment. Bethge, on the other hand, treated 60 carriers in an institution, dividing them into six groups. The first was treated with pyocyanase; the second, with hydrogen dioxide; the third, with serum (Kolle and Wassermann); the fourth, with protargol; the fifth, with one per cent salt solution; and the sixth received no treatment at all. As a result of these experiments with different methods of treatment, he concludes that hydrogen dioxide, preceded by thorough cleansing with salt solution, gives the quickest result.

The first three carriers that we discovered in the institution were given ten days' treatment with sprays of hydrogen peroxide, and also with a weak solution (1–10,000) of bichloride of mercury. This treatment, however, proved ineffectual, as cultures from these cases still showed the presence of the meningococcus, all the cultural characteristics being carefully studied. From this time on these and all other carriers were treated with sprays of antimeningitis serum, this treatment being repeated daily. As a result of this we were able to clear up the nose and throat in from 2 to 19 days, the average being 10 days. During this time, of course, the children were kept isolated, and were not released until two consecutive negative cultures were obtained from both the nose and naso-pharynx. However, we agree with Bethge in his statement that all carriers should be treated even though it may be impossible to isolate them.

CONCLUSIONS.

1. Carriers are the chief cause of the spread of cerebrospinal fever.
2. In all institutional outbreaks of epidemic meningitis, a careful and painstaking search should be made for the presence of carrier cases.
3. In practical sanitary work the identification of the meningococcus can be based on microscopic examination, this assuredly being just as reliable as the present microscopic examination of cultures for the detection of diphtheria carriers.
4. Agglutination tests are not only unnecessary for the identification of this organism, but may readily lead to erroneous conclusions since different strains of the meningococcus vary so greatly in their reaction to the same serum.

5. Opsonic experiments are of considerable value, especially when the method of dilution is employed. For the purpose of preventive medicine, however, such experiments are unnecessary.

6. Where possible all carrier cases should be isolated and treated with antimeningitis serum, the nose and throat being previously sprayed with normal salt solution. Even when isolation is impossible the cases should be treated, this subserving the double purpose of protecting the carriers and those in contact with them.

7. Release from quarantine should not be allowed until at least two consecutive cultures from both nose and throat prove negative. We do not believe, however, it is necessary to obtain the organisms in pure culture for this purpose, there being sufficient difference in size between the meningococcus and the micrococcus catarrhalis to permit a differentiation in stained specimens.

REFERENCES.

ALBRECHT AND GHON. *Wien. klin. Wchnschr.*, 1901, 14, p. 984.
ARKWRIGHT. *Jour. Hyg.*, 1909, 9, p. 104.
BETHGE. *Deut. med. Wchnschr.*, 1910, 36, p. 66.
BOCHALLI. Inaug. Diss., Breslau, 1906. Quoted from Trautmann.
DAVIS. *Jour. Infect. Dis.*, 1905, 2, p. 602.
———. *Ibid.*, 1907, 4, p. 558.
DIEUDONNÉ. *Centralbl. f. Bakt.*, 1906, 1 Abt., Orig. 41, p. 418.
FRIESE AND MÜLLER. *Klin. Jahrb.*, 1909, 20, p. 321.
GHON. *Rep. Intern. Cong. Hyg. and Demography*, 11, p. 94.
GOODWIN AND VON SHOLLY. *Ann. Rep. Dept. of Health, New York City*, 1905, 2, p. 653.
———. *Jour. Infect. Dis.*, 1906, Suppl. 2, p. 21.
HASSLAUER. *Centralbl. f. Bakt.*, 1906, 1 Abt., Orig. 41, p. 633.
———. *Ibid.*, 1906, 1 Abt., Orig. 41, p. 723.
HOUSTON AND RANKIN. *Lancet*, 1907, 1, p. 1213.
KIEFER. *Berlin klin. Wchnschr.*, 1896, 33, p. 628.
KOLLE AND WASSERMANN. *Klin. Jahrb.*, 1906, 15, p. 507.
KUTSCHER. *Deut. med. Wchnschr.*, 1906, 32, p. 1071.
LORD. *Centralbl. f. Bakt.*, 1903, 1 Abt., Orig. 34, p. 641.
MAYER, WALDMANN, FÜRST, AND GRUBER. *Münch. med. Wchnschr.*, 1910, 57, p. 1577.
OSTERMANN. *Deut. med. Wchnschr.*, 1906, 32, p. 414.
SELTER. *Klin. Jahrb.*, 1909, 20, p. 457.
SYMMERS AND WILSON. *Jour. Hyg.*, 1909, 9, p. 9.
TRAUTMANN AND FROMME. *Münch. med. Wchnschr.*, 1908, 55, p. 791.
VON LINGELSHEIM. *Deut. med. Wchnschr.*, 1905, 31, p. 1017.
———. *Klin. Jahrb.*, 1906, 15, p. 373.
WEICHSELBAUM AND GHON. *Wien. klin. Wchnschr.*, 1905, 18, p. 625.